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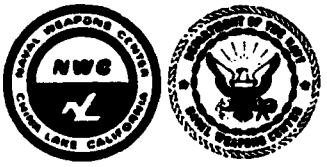
Navy Geothermal Plan

by
Energy Program Management Office

DECEMBER 1984

NAVAL WEAPONS CENTER
CHINA LAKE, CA 93555-6001



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FOREWORD

This report outlines the Navy Geothermal Plan, a program aimed at providing the basis for utilization of geothermal resources to supply electrical power and space heating and cooling at appropriate naval shore installations. The Navy Geothermal Plan was produced by a joint effort of the Naval Material Command, the Naval Facilities Engineering Command to include the Western Division, the Naval Civil Engineering Laboratory, and the Energy Program Management Office at the Naval Weapons Center.

This report was reviewed for technical accuracy by LCdr. T. Boothe, R. Wickman, and W. G. Bossert.

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(U) Domestic geothermal resources with the potential for decreasing fossil fuel use and energy costs exist at a significant number of Navy facilities. The Geothermal Plan is part of the Navy Energy R&D Program that will evaluate Navy sites and provide a technical, economic, and environmental base for subsequent resource use. One purpose of the Program will be to provide for the transition of R&D funded exploratory efforts into the resource development phase. Individual Navy geothermal site projects are described as well as the organizational structure and Navy decision network.

CONTENTS

Figures:

INTRODUCTION

OBJECTIVES

The objectives of the Navy Geothermal Program are to (1) provide a technical, economic, and environmental data base to prevent encroachment pressure of private exploration efforts from degrading the ability of the individual bases in performing their assigned missions and to (2) use geothermal resources to supply electrical power and space heating and cooling at appropriate naval shore installations.

The Navy Geothermal Plan is a coordinated approach to attain the above-stated program objectives. This approach will be accomplished by (1) an R&D program that will include a phased exploration effort to provide the technical information on the existence of a resource and a utilization effort to determine how and what methods should be employed to make use of the resource, and by (2) a resource development program that will provide solicitation, award, administration and management of a contract for the development of the geothermal resource. The organization structure and responsibilities required to provide this coordination are presented in this report.

BACKGROUND

Geothermal resources have been economically employed at a number of worldwide locations for generating electric power and providing space heat. These resources may exist at a significant number of Navy bases and have the potential to effect a substantial long-term decrease in fossil fuel usage and Navy energy costs. The geothermal resources at some Navy sites appear to be of high temperature and capable of providing heat and electricity for the host base and also exporting excess electrical power to other Navy and Department of Defense (DOD) installations. At other Navy sites, the resources are of low temperature, but can provide for heating/cooling.

In recent years, there have been increasing encroachment pressures of various types, including private energy exploration, that may remove from Navy control lands containing geothermal and other energy resources. This loss of control, in many cases, will have a severe adverse impact on the intended mission of the activity. The Navy is continuing to counter encroachment by maintaining a coordinated program in geothermal development that includes a determination as to whether the Navy should (1) not allow development, (2) allow the Bureau of Land Management (BLM) to lease property with constraints, or (3) provide for Navy development. Under the latter, a contract with a private developer would be awarded to complete the evaluation of the resource, develop the geothermal field, construct the facility, and operate the plant at no capital cost to the Navy.

The Navy has contracted for geothermal development using this venture capital contracting method at the Naval Weapons Center (NWC), China Lake, Calif., and at the Naval Air Weapons Training Complex (NAWTC) Fallon, Nev. The Navy has also amended the Public Land Order withdrawal at NWC to allow BLM to lease, with constraints, certain Navy withdrawn lands for geothermal exploration and development. The Navy is continuing to investigate other potential geothermal sites (see the Appendix).

RESOURCE DEVELOPMENT OPTIONS

Geothermal energy is a site-specific resource and, as such, is an indigenous resource that cannot be easily disrupted by actions that would breach ordinary supply lines to the activity. The Navy Energy R&D Program identifies the existence of this resource and utilization methodologies for the activity and advises on the practicality of developing the resource.

Electrical Generation

The resource must be tapped by drilling. Fluid temperatures must be between 300 and 660°F (or 150 and 350°C) for electrical power generation. Power plant type and size will depend on the needs at the site and the nature of the available geothermal fluids. Remote sites may dictate use of small power plants or wellhead power generation to match the limited power requirement.

Space Heating/Cooling

Geothermal heating includes the development of the geothermal field through drilling a sufficient number of wells to provide the needed heating fluids. Fluid temperatures must be between 150 and 212°F (or 66 and 100°C) for space heating applications. If the fluids are relatively clean, they can be piped directly to facilities to provide heat and sometimes hot water. If the fluids are contaminated or corrosive, a heat exchanger will be required to transfer the heat to a fresh-water system for transport to the using site.

Geothermal resources below 150°F (or 66°C) may also be used for space heating in conjunction with water-source heat pumps, although each potential application must be carefully analyzed to determine the life-cycle economics.

Joint Electrical Generation/Space Heating

If both power and heat are needed at a given Navy base and the resource is suitable, it may be encouraging to use geothermal fluids for both functions. The economics of using geothermal fluids or electrical energy from the geothermal power plant will depend on the individual site and the distance fluids must be transported.

MANAGEMENT PLAN

ORGANIZATION

The Navy has defined roles and responsibilities for its eventual use of geothermal energy within its existing organization. By delineating responsibilities within the Navy, geothermal development will be integrated into the long-range planning of activity missions and requirements. To this end, the Navy is using the coordinated parallel path organization structure shown in Figure 1.

The Navy Energy R&D Program is established by the Chief of Naval Material through the Energy and Natural Resources R&D Office (MAT-08E). It is their concern that energy R&D and acquisition programs be structured to maintain a balanced energy program and to meet the energy goals as identified in OPNAVINST 4100.5B. The Naval Facilities Engineering Command (FAC-032E) is responsible for defining energy-related requirements to the Naval Civil Engineering Laboratory (NCEL) (L70PM) for execution of the Navy Shore Facilities Energy R&D Program, which includes "Geothermal Energy" as one of its subprojects.

The Energy R&D Program Manager's (FAC-032E) role is to keep in close contact with the Energy Coordinator (FAC-111B) for the Assistant Commander for Energy and Environment (FAC-11) and other NAVFAC codes to ensure that sites to be investigated by the geothermal portion of the R&D program are those that require attention because of operational expansion and mission-related problems such as encroachment. The NCEL Energy R&D Program Manager (L70PM) through his Renewable Energy Program Manager is the executing agent for the Navy Shore Facilities Energy R&D Program, which includes the geothermal efforts.

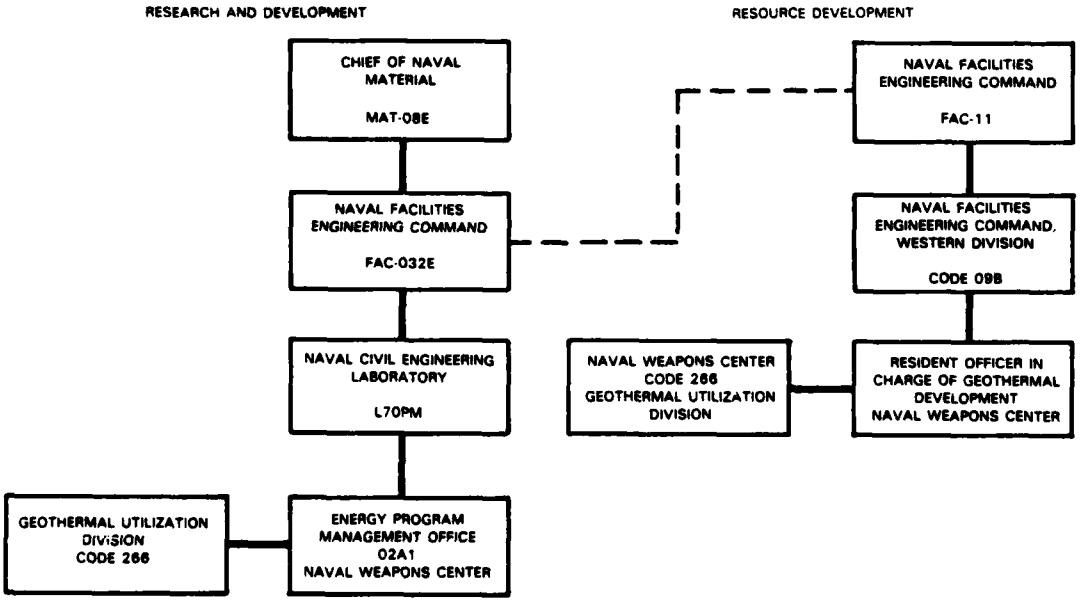


FIGURE 1. Organizational Structure Under the Two Phases of the Navy Geothermal Program.

The technical investigations are then performed by the Geothermal Utilization Division through the Energy Program Management Office of NWC as tasked by NCEL. The Geothermal Utilization Division develops a programmatic survey for each site as part of the Navy Shore Facilities Energy R&D Program Plan. The Geothermal Utilization Division executes this plan during the appropriate fiscal year and documents the results that are then used as the basis for development by the Resource Development side of the organization chart of Figure 1.

Under the resource development effort, the Assistant Commander for Energy and Environment, after reviewing the results from the R&D Program, will recommend whether or not to proceed with development. Criteria for decisions are based on the encroachment hazards, the indicated energy potential, and the economic practicality of the proposed project. Upon concurrence by the major claimant and the local activity involved, development is executed by Western Division, Naval Facilities Engineering Command (WESTDIV-09B), which has been designated as the geothermal contracting agent for the Navy. All geothermal development contracts will be administered by WESTDIV through a Resident Officer in Charge (ROIC) of Geothermal Development who has direct access to the technical expertise of the Geothermal Utilization Division at NWC.

RESPONSIBILITIES

The Navy has established the decision network (Figure 2) to ensure proper cooperation and coordination in developing geothermal potential on Navy lands by the appropriate methods.

Recommendations to evaluate sites are made throughout the R&D resource assessment program (see the Appendix). At those sites that show promise, a preliminary resource is assessed along with a review of the land and mineral rights status proving ownership of identified lands. The local activity and the major claimant are given briefings prior to the initiation of the assessment program and after the resource has been evaluated. The decision is made that the program should be continued or that no further work is warranted.

The development options are considered to prevent encroachment pressure by a lockout, a military-controlled development, or a Department of Interior (DOI)/BLM lease. Under a lockout or DOI/BLM lease, the R&D program provides for the minimum assessment of the resource that will protect the Navy's interest. Under military-controlled development, the geothermal program verifies the resource with a full R&D effort and recommends the approach to resource development based on technical and economic considerations. The implementing procedures include an acquisition strategy, solicitation documents, and a government cost estimate.

It should be noted that while the geothermal plant may be privately developed, the Navy retains title to the land and the geothermal resource. If required, the Navy will arrange for the transmission or other use of power over long distances with a regional federal agency, or the contractor will arrange for this service directly. Also under the military-controlled development option, an ROIC of Geothermal Development is delegated the responsibility for administrating the contract and establishing an organization to perform field development operations, including management of the resource for the duration of the contract period.

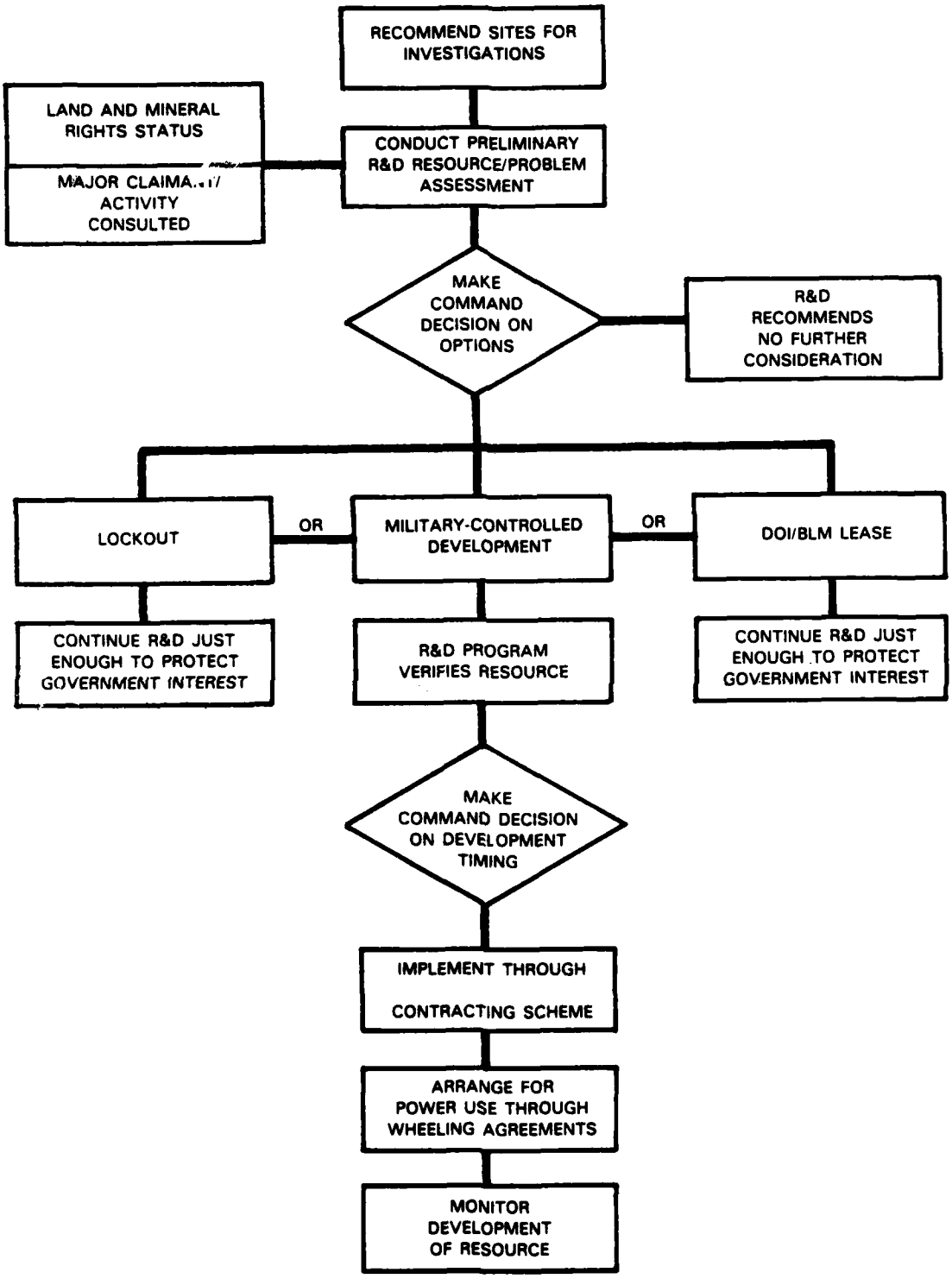


FIGURE 2. Navy Decision Network for Geothermal Development.

RESEARCH AND DEVELOPMENT

R&D PROGRAM EXECUTION

All resource assessments including the resource utilization support analysis will be accomplished by NWC in-house personnel using Navy-owned equipment. Only those assessments requiring costly specialized equipment and surveys of a one-time nature that cannot be performed by available in-house expertise will be contracted out on a specific task basis.

The results of the R&D effort are published in the form of technical and administrative publications and technical memoranda. Results of this research will also be published in technical and scientific journals and may be patented as appropriate. Abstracts and articles will be presented at geothermal meetings, conferences, and symposia.

RESOURCE ASSESSMENT

The Navy Plan provides for a tiered program of exploration that will evaluate such conditions as porosity, permeability, fluid temperature, and fluid chemistry for a geothermal prospect. It should be noted that the industry success rate of exploration to date in all western KGRA (Known Geothermal Resource Areas) is 0.113 or 11.3% for developing a project capable of electrical generation based on satisfying all the above conditions. The Navy's geothermal program is different from industry's in that fixed land positions are to be evaluated. Thus, it is probable that not all Navy prospects will be productive. It is estimated that of the sites evaluated in the geothermal program, one viable geothermal prospect will be produced each year.

Preliminary Site Survey

Generally, some type of surface manifestation will be associated with a subsurface geothermal resource. This manifestation could be anything from bubbling hot springs, vents, and recent volcanic activity to secondhand information about hot water being pumped from a nearby well. When this type of information is available on or near a particular site belonging to the Navy/Marine Corps, the literature is reviewed extensively to determine whether or not that site shows sufficient potential to warrant detailed site specific exploration. At the same time, a search for apparent ownership of Navy lands and mineral and water rights status is coordinated with the Planning and Real Estate Divisions at appropriate Engineering Field Divisions (EFDs).

The site is visited for visual verification of any geothermal resource manifestation with a general geologic reconnaissance that would include any identification of structures that may act as a conduit to the surface for geothermal fluids. Along with this reconnaissance, any available air photos are interpreted for faults, lineations, hot spring deposits, and hydrothermal alteration.

A regional geochemical survey can be undertaken at the same time that includes the water sampling of hot, warm, and cold springs for chemicals, and soil sampling for trace element content. This information can be used for advanced site work.

Advanced Site Survey

If the results of the preliminary survey are positive, advanced work is undertaken that includes geophysical surveys. Geophysical surveys measure the variations in the physical properties of subsurface rocks that can indicate the existence and possible extent of geothermal resources. Because each geothermal prospect is unique, there is no one method or series of methods that will work in all circumstances. The costs of various methods must be considered in terms of the benefits received and the value of the particular resource.

Geophysical techniques can be placed into three categories: structural methods, electrical methods, and passive seismic methods. Geochemical analyses are also made, as described below.

Structural Methods. These methods include gravity surveys, magnetic surveys, and active seismic methods. These methods measure the minute changes in densities of the subsurface rock, and thus give a good location of subsurface faults, depth to basement in sedimentary basins, and at some sites the existence (or lack) of a cap rock over a geothermal reservoir.

Electrical Methods. Electrical methods are used to determine vertical and lateral variations in subsurface electrical resistance. Electrical resistance decreases as subsurface temperatures increase, as the clay content of the subsurface increases, or as the salinity of the subsurface increases.

Passive Seismic Methods. A characteristic of geothermal areas is that they have more microearthquake activity than other areas. One method the Navy uses is the microseismic survey, which will detect such activity. Identifying these microearthquakes and their exact location will determine active fault zones in a geothermal area since the faults may be acting as conduits for geothermal fluids.

Geochemical Techniques. Geochemical investigations provide data about subsurface temperature, locations of faults that act as conduits for upward movement of hot waters and gases, sources of potential scaling or corrosion during production, and possible waste disposal problems and environmental concerns.

Resource Confirmation

The exploration methods discussed under the sections titled "Preliminary Site Survey" and "Advanced Site Survey" are extremely important in selecting sites for test drilling. However, test drilling is the only way to confirm the presence of a geothermal resource. (Test wells are distinguished from production wells, which are normally the responsibility of the production contractor.)

Careful planning of the drilling program will therefore ensure obtaining information about the size and value of the resource at least cost so as to reduce risk and establish the value to the Navy. The R&D Program provides a drill plan of basic well design that includes monitoring Geothermal Resources Operation Orders (GROs),* recovery of samples (core or chip), geophysical logging (self-potential, gamma ray, and thermal gradient), and flow testing. The data will allow proper assessment of the geological, geophysical, and geochemical data previously acquired. Such reassessment will provide a better understanding of the nature and extent of the geothermal resource.

Reservoir Analysis

Reservoir analysis begins with exploration and continues throughout the life of the field. After a production contractor is on site, WESTDIV is responsible for resource management, with technical assistance from the Geothermal Utilization Division, NWC.

Flow testing of test wells is the most important tool of reservoir engineering. On single wells, the mass flow, wellhead temperature, enthalpy of fluids, drawdown, and pressure buildup after shut-in are measured. When more than one well is available, interaction between wells can be determined. As these data are obtained, the size and life of the field can be assessed. Management parameters such as optimum well spacings, depths, and production rates are then decided to ensure that the Navy geothermal field is not depleted unnecessarily.

RESOURCE UTILIZATION SUPPORT ANALYSIS

Supporting analysis will provide the knowledge to evaluate a site with respect to nongeoscientific factors. Significant areas of institutional and technical support are common to all geothermal sites and also peculiar to the needs of site development of Navy lands. These areas include (1) environmental issues and data base support that determine the effects of geothermal development at each specific site and the effects of inherent geothermal vapor emissions on air quality, (2) identification of chemical corrosion impacts on existing Navy/DOD electronic and avionic equipment, (3) utilization methodologies that will enable the Navy to investigate new or existing technologies and applicable equipment or mechanisms for alternatives should the geothermal resource prove to be inadequate for direct steam turbine electrical production, and (4) investigation of alternate energy production and direct utilization processes that will consume small amounts of energy in comparison to geothermal electrical plants, but collectively displace a significant amount of energy from conventional sources.

Environmental Support

Geothermal energy is not a totally clean, pollution-free energy source. Particulate emissions, which concern the Navy, result from the drying of mists emitted from some cooling

*Geothermal Resources Operation Orders are issued under the Geothermal Steam Act of 1970 and administered by DOI (Bureau of Land Management). Each operational order sets forth provisions to conduct various geothermal operations from exploration through field closure.

towers and from dust caused by construction and operation activities. Baseline air quality will be established for comparison with the concentrations after geothermal development. Pollutant constraints will be established for use in all development contracts whether by the Navy or by DOI on or near Navy bases.

NWC develops preliminary environmental information for overviews and assessments to permit thermal gradient drilling and in keeping with the tiered approach to environmental impact statements that include (1) environmental overview (EO), (2) environmental assessments (EA), and (3) environmental impact statements (EIS).

Corrosion/Deposition Assessment

Corrosion and deposition are problems common to all geothermal sites because of the variety of chemicals found in geothermal fluids. However, each site has its own distinctive characteristics. All known sites will produce significant quantities of sulfur-containing gases such as H_2S that, when combined with moisture and air, form very corrosive acids. Corrosion investigations assess the impact of dissolved gases and the chemical species associated with geothermal fluid on Navy equipment and develop, when necessary, methods for mitigating such impacts. A recent Navy publication resulting from this effort describes the corrosive effects on military electronic/avionic equipment under long-term soak tests.

Utilization Methodologies

Geothermal resources hold great promise for supplying needed energy for heating, cooling, and electrical power at many Navy bases. A technical/economic analysis will therefore be made to determine whether the site is worth developing. As additional data become available, the analysis is continually updated and examined in greater detail with respect to the activities mission, waste management, and utilization techniques. Based on these data, the engineering system economics can be determined, and the decision to develop the site can be made.

Technology Base Modeling

Because many Navy sites are entities unto themselves and often isolated, the approach to tapping geothermal energy will often differ from that used in large commercial ventures. A sustained effort is required to monitor Department of Energy (DOE) and commercial development in the field of geothermal utilization, identify and promote that technology important to the Navy geothermal program, and develop experience through joint technology demonstration efforts with DOE at Navy sites.

Reservoir modeling will be performed to determine and understand past, present, and future behavior of geothermal reservoirs so that the R&D program can better forecast the economic recovery required to prepare sound plans for development and operating of these reservoirs.

REPORT OF EXPLORATION

The Geothermal Utilization Division shall, at the completion of the exploration phase, prepare a report recommending how the resource would best be developed if a decision is

made to proceed. This report will include recommendations and summarize technical, economic, and other justifications to support recommendations in the following areas: (1) resource utilization (for example, power production and direct utilization), (2) source and magnitude of funds required for the project (such as military construction, venture capital, and consortium with other agencies), and (3) method of procurement.

RESOURCE DEVELOPMENT

AUTHORITY

The various military departments within DOD are authorized by 10 USC 2689 to develop geothermal resources on federal lands under the control of the respective military department. 10 USC 2394 also authorizes contracts with terms of up to 30 years where appropriate for the amoritization of costs if the development is done at contractor expense.

RESPONSIBILITY

The Commanding Officer, WESTDIV, serves as OIC of Geothermal Development contracts. As such, WESTDIV, using the report of exploration as a source, is responsible for preparation of the acquisition strategy, solicitation documents (including technical specification), operating constraints, and the government cost estimate. Additionally, the OIC is responsible for administration of the contract, once awarded, and the establishment of an organization to perform field administration.

ACQUISITION STRATEGY

If the contract is to exceed 10 years, the OIC will prepare an acquisition strategy that defines the overall plan to obtain the objectives detailed in the development recommendations. It will encompass major aspects of the project that include technological options and reliability, schedules, business considerations, contracting options, logistic support, manning, and training. The acquisition strategy, when complete, is forwarded to NAVFAC, Code 11, for approval prior to program execution. The Chief of Naval Material (CNM) shall approve acquisition strategies for programs whose decision authority is above the NAVFAC level.

SOLICITATION

Normally, the contract will be advertised as an Invitation for Bid (IFB) using Standard Form 33. Other contract options including Request for Proposals (RFP) and two-step procurement processes may be used if deemed more appropriate for any given procurement action.

The solicitation document is composed of several parts. Part I includes contract form, services and prices, project description specifications, packaging and marking, inspection and acceptance, deliveries of performance, contract administration data, and special provisions.

Part II is the General Provisions. Part III is the List of Documents, with exhibits, and other attachments to the contract. Part IV is General Instructions, with appendixes concluding the contents.

The actual contract contents and format will depend to a great extent on the financial arrangements for payment of project costs. There are, as of this writing, two courses for this to take—Navy-funded (MILCON or O&MN) or contractor-funded. Under the former, the contract would closely parallel normal content/format with special provisions made primarily for the nature and risk of geothermal development. The Navy is expected to retain its traditional role of authority and responsibility. Under the contractor-funded project, both risk and responsibility shift to the contractor, with the Navy's interest primarily directed to positive control of its operations and to ensuring that environmental and safety requirements are upheld. The remainder of this discussion of resource development will assume the less traditional option of a contractor-funded project.

SPECIAL CONTRACT PROVISION

The contractor may be granted the sole right to investigate, explore, and develop the resource as defined in the contract; however, the Navy retains title to the land and the resource. The exploration and development of the resource will be divided into phases of work. Development may be limited where appropriate, and operating constraints may apply to the contractor to prevent interference with the mission of the installation.

Generally, the Navy desires the prompt development of the contractual-agreed potential of its geothermal resources. A development schedule is normally included in the contractual documents. Development and extraction of geothermal by-products will require specific Navy approval and will be accomplished in accordance with existing law. The developer in turn will finance, design, build, and operate the facility supplying electrical and/or heating/cooling services. Cost to the government will be the developer's bid price for the product (electricity or heat) provided. That bid price will be adjusted periodically by an index designed to reflect changes in the developer's costs for providing the contracted product. A ceiling rate will be included to ensure a savings compared to regular commercial utility charges.

All work under a geothermal contract shall be performed in accordance with the GROs, except where specified differently in the contract.

ENVIRONMENTAL DOCUMENTATION

The local activity will have prepared a Programmatic Preliminary Environmental Assessment (PPEA) prior to contract award. It will be the contractor's responsibility to prepare at his cost all other environmental documentation necessary to fulfill the National Environmental Policy Act and other federal and state requirements for each phase of development as indicated in the PPEA.

Prior to undertaking any on-site work, the contractor will be responsible for the specific investigation of archaeological and historical resources. Contingency plans shall be prepared and contain plans for immediate implementation of corrective actions for emergency situations resulting from operational mishaps or equipment failure that may cause hazardous conditions

(for example, blow-outs, waste-water spills, excessive emissions to the atmosphere, and fire and safety hazards). The contractor will acquire all permits or licenses required by federal, state, Navy, and local agencies, comply with all environmental requirements, and maintain all required records. The government retains responsibility for monitoring all phases of the projects.

GOVERNMENT COST ESTIMATE

The OIC WESTDIV will be responsible for preparing the government cost estimate. This estimate will be based on the assumption that any payment made by the government will be made solely for energy consumed. The sole cost to the Navy will be a price per unit of energy.

The basis for bid will normally be the unit price per kilowatthour ($/kWh) of electrical energy delivered or the unit price per million British thermal units ($/MBtu) consumed or both.

CONTRACT ADMINISTRATION

ADMINISTRATION

WESTDIV, as the OIC, is the designated administrator for geothermal contracts for the Navy. To assist with technical and contractual support and more effectively manage geothermal contracts at the field level, WESTDIV has designated the Public Works Officer, NWC, China Lake, as the ROIC of Geothermal Development.

ROIC OF GEOTHERMAL DEVELOPMENT

The ROIC of geothermal development serves as the sole interface between the contractor and the government. The ROIC has been delegated the responsibility of general surveillance of the contractor's development activities and to ensure that all field operations are in compliance with the terms and conditions of the development contracts, including the applicable GROs.

The ROIC performs field inspections of contractor operations and processes all correspondence, scheduled submittals, and data packages and coordinates between the contractor and all other Navy agencies.

To assist in the accomplishments of these tasks, NWC has authorized its Geothermal Utilization Division and the Environmental Branch of the Public Works Department to support the ROIC of Geothermal Development in the performance of his duties.

RESOURCE MANAGEMENT

RESERVOIR MANAGEMENT

Proper management of a geothermal resource to ensure protection of Navy equity is necessary to optimize the use of the energy reserves stored in the reservoir and help ensure the longevity of the resource.

Accumulation of field data will begin as soon as possible to establish a baseline for the unexploited reservoir. Early implementation of a field monitoring system is vital to future interpretations.

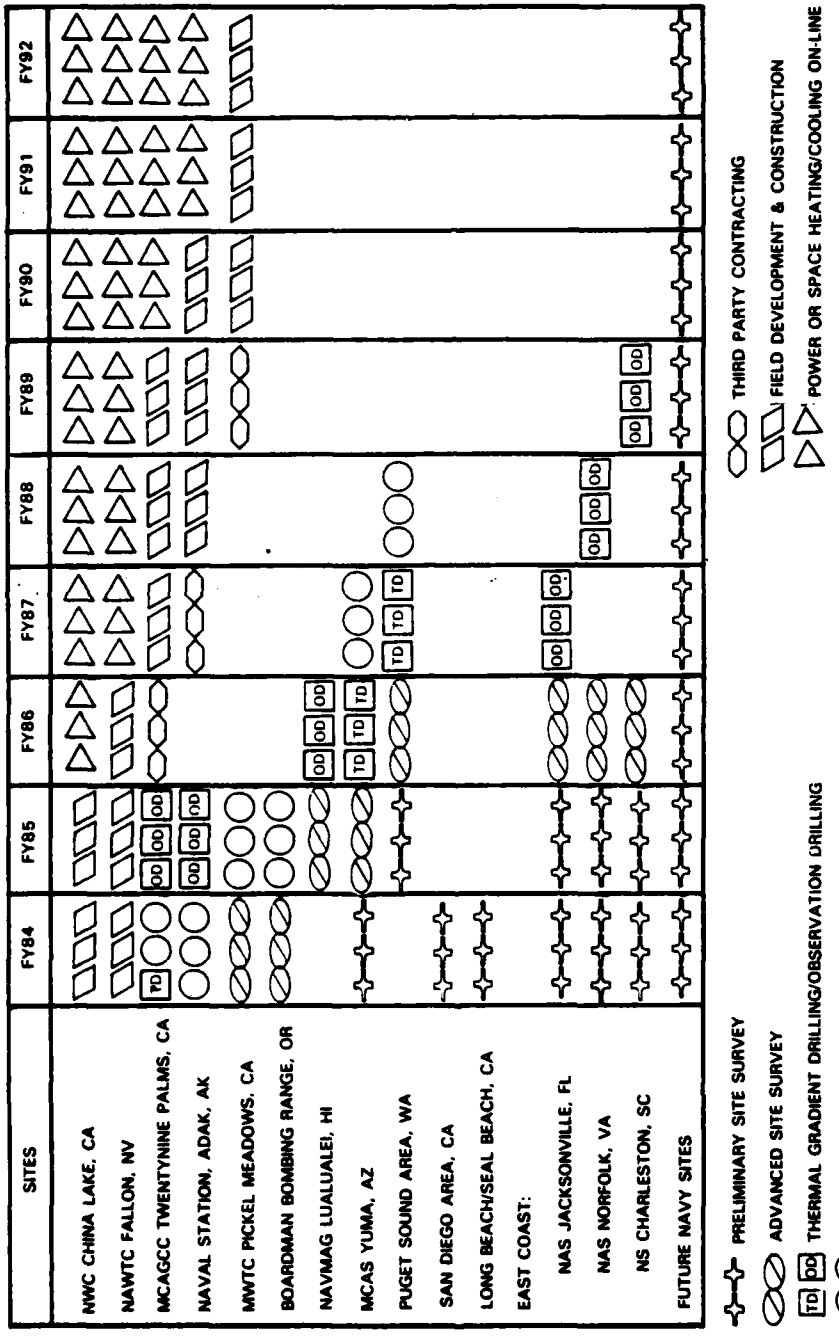
A reservoir model enables the Navy as the reservoir manager to establish the characteristics of the reservoir and prediction methodologies to determine the response to planned production operations, and to estimate the longevity of the resource for better management strategies during development.

UNITIZATION

The Geothermal Steam Act of 1970 for Unit Plan Regulations prescribes the procedure to be followed and the requirements to be met by holders of federal geothermal leases. The Unit Operating Agreement is a plan for development and operation of separately owned interests in a common geothermal resource made subject thereto as a single consolidated unit without regard to separate ownerships and which provides for the allocation of costs and benefits on a basis defined in the agreement or plan. With a Cooperative Agreement Plan, the resource is under separate ownership and all interests independently but cooperatively operated.

Depending upon the circumstances, the Navy may participate in negotiations to establish one or a combination of these agreements. The responsibility for conducting these negotiations lies with the OIC of Geothermal Development at WESTDIV.

Appendix
LISTING OF PLANNED GEOTHERMAL ASSESSMENT AND IMPLEMENTATION PRIORITIZATION (FY 1984-FY 1992 +)



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1 Air Force Intelligence Service, Bolling Air Force Base (AFIS/INTAW, Maj. R. Leckliider)
2 Tyndall Air Force Base, Florida
    AFESC-DEB (1)
    AFESC-RDCS (1)
1 Deputy Assistant Secretary of Defense (Energy, Environment and Safety)
12 Defense Technical Information Center